Background and Purpose of Condition Assessment

The intent of this condition assessment is to independently evaluate the condition of Going-to-the-Sun Road. This assessment includes both a review of what had previously been investigated, concluded, and recommended regarding the condition of the Road, and two independent field reconnaissance missions, one in the fall of 2000 and one in early summer 2001.

Field reconnaissance was conducted on the Road in late August 2000. Field efforts were successful in providing most of the information necessary to complete this task. To better define the means and methods of rehabilitation, this field work was supplemented in June 2001 with a second field reconnaissance of the Road. Equipped with a good understanding of the issues, the second field reconnaissance team developed engineering options and constructibility reviews, and field-proofed traffic management options for each of the areas in need of rehabilitation.

The field reconnaissance completed to-date has resulted in the following general conclusions about the condition of the Road. These conclusions are also supported by the literature reviews and discussions with park and FHWA personnel.

- Emergency repairs are needed in certain critical areas to keep the Road open and operational in the short term.
- An overall roadway rehabilitation plan is needed to keep the Road open into the future.
- After rehabilitation, a long-term maintenance plan and additional maintenance funding are needed to preserve the Road's integrity.

General observations about the condition of the Road are discussed in the body of this chapter. Detailed and site-specific observations are discussed in *Chapter 2: Engineering Analysis and Site Recommendations,* and in the Appendices.

*Whether a feature of the Going-to-the-Sun Road is determined to be a contributing or non-contributing historic element is based upon judgment of **integrity** and **significance** by the historic and cultural landscape consultant.*
***Integrity**, as used here, indicates the degree to which the feature continues to evoke its historic associations. There are four degrees of integrity:*
<u>Retained Integrity:</u> the feature almost wholly retains its historic appearance
<u>Diminished Integrity:</u> the feature retains an overall historic appearance, although modern changes are also readily apparent.
<u>Lost Integrity:</u> the feature has lost its visual historic associations, although some historic or historic-type materials may still be present.
<u>Modern Integrity:</u> the feature evokes no historic associations, and is constructed of modern materials.
***Significance** refers to the continued ability of the feature to count as a contributing element in a hypothetical National Register of Historic Places evaluation of the resource. All features with retained integrity, and most with diminished integrity, are classed as contributing; all others are non-contributing.*

Going-to-the-Sun Road was originally built in the 1920s and 1930s, and improved extensively between the 1930s and 1950s. Roughly 23 of the Road's 50 miles have been completely rebuilt in the last decade. Most of these recent rehabilitation projects have been on the lower portions of the Road. Many areas of the highly sensitive and deterioration-prone alpine sections have yet to be rehabilitated. As a result of continued roadway deterioration and inadequate maintenance and rehabilitation funding, the condition of the roadway is considered critical with respect to safety, serviceability, and retention of historical features.

Rehabilitation recommendations take into account preservation of the historical features of the Road. As the Going-to-the-Sun Road is a National Historic Landmark, the Road and many of its structures were contributing features in the Road's designation as a National Historic Landmark. As such, the Road and its structures are protected by Federal law and must be preserved by the National Park Service. The historic and cultural perspectives are provided by the authoring team's historic and cultural landscape consultant and are intended to explain, in general terms, what may be appropriate when it comes to the effects of proposed rehabilitation on contributing features.

The evaluations presented in this report are conceptual in nature, as is appropriate for this point in the evaluation, analysis, and design process. The information from this report will help establish alternatives for evaluation in an environmental impact statement (EIS) for the rehabilitation. The result of the EIS process will be the identification of a preferred rehabilitation alternative. Once the preferred alternative is identified in the EIS process, specific and detailed field investigation and design can commence.

Figure 4:
Going-to-the-Sun Road

Summary of Literature Review, Interviews, and Construction Plan Review

Existing engineering studies and reports listed in Appendix H were reviewed to determine the extent, completeness, timeliness, and usefulness of information available on the condition and needs of the Road. Personal interviews were conducted with various FHWA and NPS personnel, as well as private individuals. The purpose of the interviews was to glean as much information as possible from those most familiar with the Road, as well as to identify the current practices used for rehabilitation and maintenance of the Road. Construction plans for emergency rehabilitation projects currently occurring on the Road were also reviewed.

In general, the prior engineering reports provided an evaluation of the condition of the Road, inventoried and evaluated the condition of the retaining walls, and qualitatively described the drainage structure deficiencies along the Road. Several of the documents reviewed were summaries of field review meetings or correspondence sessions between personnel from the NPS and the FHWA. From the review of available information, it was concluded that several documents existed which articulated the deficiencies of the roadway and the scope of rehabilitation planned for the Road. The 1984 Road Rehabilitation Study provided good descriptions of the needs of the Road.

Subsequent studies provided information and analysis on specific issues of the Road, and in particular, FHWA studies and plans for retaining wall rehabilitation. Some studies addressed alternative designs and innovative methods of rehabilitation, and much of the work in the last several years incorporated these alternatives and methods. Innovative concepts in design and methods used in the last several years are now considered standard rehabilitation measures or alternatives in ongoing rehabilitation efforts. Emergency repair plans and specifications for projects slated for construction between 2000 and 2002 were reviewed and found to adequately address the emergency needs at each site.

Several locations of pavement and structural distress have recently developed which were not evident upon completion of the previous engineering analysis. Consequently, these areas of distress were not included in any prior planning or cost estimates.

Field Reconnaissance

A field reconnaissance and condition assessment of the Road was conducted during the week of August 28, 2000. During this reconnaissance, pertinent information was gathered to assist in determining the condition of the roadway, developing traffic management and engineering alternatives, and analyzing constructibility issues and the sufficiency of roadway maintenance. Visual observations were made to verify existing conditions and to document deficiencies and rehabilitation options. These observations covered the general condition of the roadway, pavement, structures, drainage, fill sections, back slopes, and safety features. No subsurface investigations were made. Also noted were contractor activities, and traffic safety and management at two construction sites.

The general condition of the Road was observed visually with the intent of verifying existing conditions and documenting, in a broad sense, deficiencies and rehabilitation options. During the field review, special attention was paid to opportunities for innovative design, traffic management, and construction. Sensitivity was given to historic preservation, visitor experience, safety, practicality (design, construction, and future maintenance), preservation of natural resources, socioeconomic impacts, roadway specifications, and construction alternatives.

During the spring of 2001, it was determined that additional investigation of the Road's condition and field-proofing of the rehabilitation alternatives would add considerable value to the study. During the week of June 25, 2001, a second field reconnaissance and condition assessment was conducted, using a team with comprehensive experience in design and construction management in mountainous, environmentally sensitive terrain. During this reconnaissance, the focus was on identifying engineering alternative solutions and developing concepts that would provide the rehabilitation with value in constructibility, cost effectiveness, visitor management, and historic, cultural, and environmental sensitivity.

Visual observations were made to verify existing conditions, document deficiencies, and identify rehabilitation alternatives. These observations covered drainage, slope stability, retaining walls, guardwalls, the roadway, and potential staging areas. No subsurface investigations were made. Concepts were identified for correcting the deficient areas. Development of cost-effective, feasible solutions within the constraints of environmental, historical, and cultural parameters provided the basis from which to determine the most appropriate traffic management strategy for the areas of work.

Organization of Information and Mapping within this Study

To develop the overall condition assessment of the Road, the project team conducted literature reviews, interviews, meetings, and field reconnaissance. The resulting information is organized into three levels of detail:

- An overview of the conditions of drainage, slope stability, retaining walls, guardwalls, and roadway pavement is included in this chapter, covering the specific issues investigated. *Chapter 2: Engineering Analysis and Site Recommendations* provides a summary of the conditions and feasible solutions, organized by section and Road segment. Based on general topography, the Road was divided into five sections:

    1. Lake McDonald Section - MP   0.0 to 16.2;
    2. West Tunnel Section - MP 16.2 to 23.4;
    3. Alpine Section - MP 23.4 to 34.3;
    4. Baring Creek Section – MP 34.3 to 43.2; and
    5. St. Mary Section – MP 43.2 to 49.7.

- Within these sections, the Road is further divided into segments of approximately one mile or less. Road segments were delineated by their location, type of work required, constructibility, and traffic management options. The second level of detail is provided for these segments in *Chapter 2: Engineering Analysis and Site Recommendations*.

- The most detailed level of information is found in the appendices, where location maps and spreadsheets show deficiencies, feasible solutions, and cost estimates by Road segment.

Over the years, mapping of the Road included inexact milepost designations and stationing. This has led to discrepancies in milepost and stationing among reports. For the purposes of this study, mapping used for the fieldwork and reporting is the mapping generated for the Cultural Landscape Inventory, and includes the various stationing and milepost locations reported to be the most accurate available at this time. During the field reconnaissance, field measurements were approximated and consid-

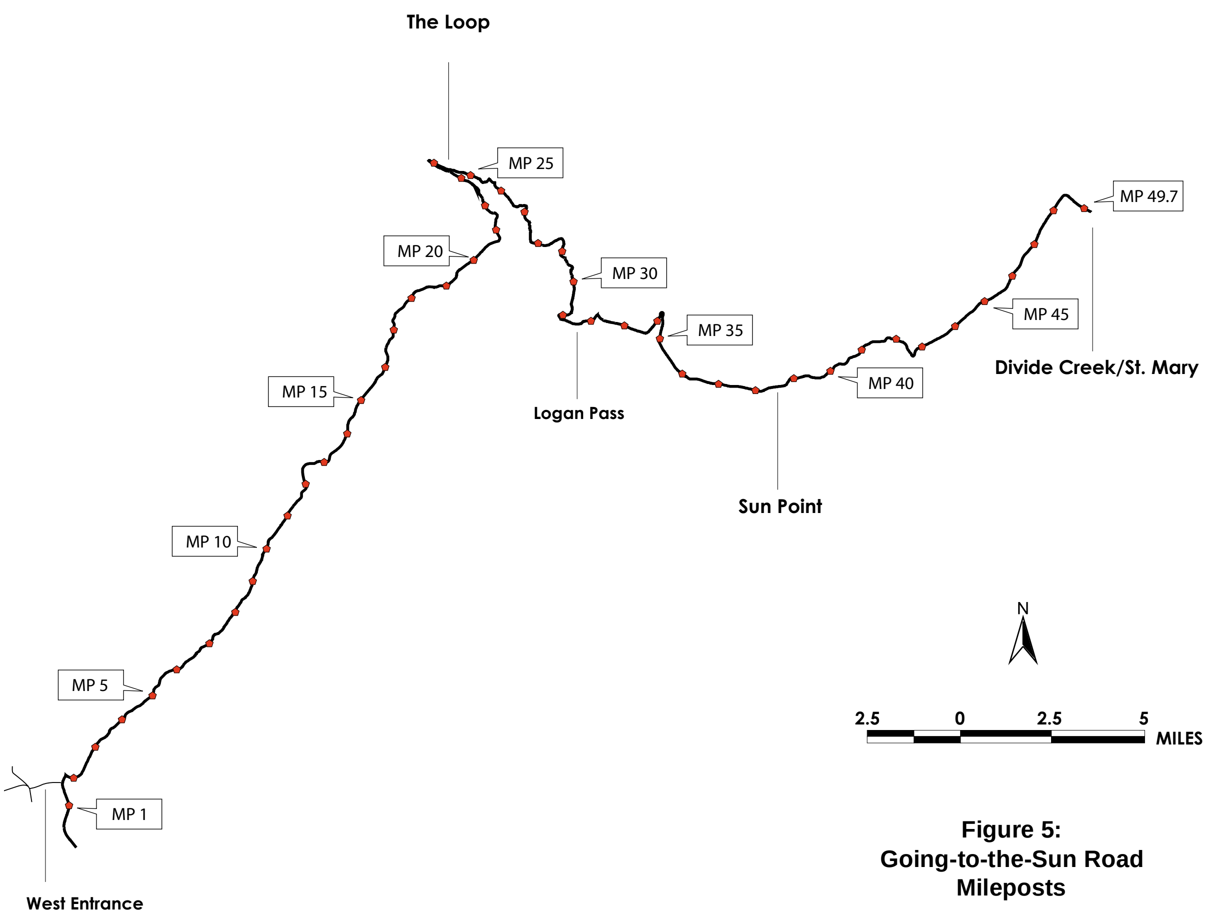

Figure 5:
Going-to-the-Sun Road Mileposts

ered adequate for the level of this study. Figure 5 shows the approximate milepost (MP) locations.

Overview of Condition Assessment

The findings of this condition assessment have been developed as an overlay to NPS-furnished Geographic Information System (GIS) mapping, showing the locations of potential staging areas, avalanche chutes, roadway intersections, traffic pullouts, parking areas, guardwall/rail termini, retaining wall termini, architectural features, drainage structures, and other pertinent information.

The condition assessment was intended to determine the basic condition of the roadway and provide information pertinent to developing feasible and constructible options, traffic management alternatives, roadway rehabilitation strategies, maintenance management options, and other conceptual engineering considerations. Analysis was done at a conceptual level. Additional detailed and comprehensive field work, including materials sampling, design survey, hydrologic study, and geotechnical investigation and analysis, should be part of the preliminary design of each individual rehabilitation project. An overview of the findings of the field reconnaissance missions is summarized in terms of:

- Drainage
- Slope Stability
- Retaining Walls, Arches, and Tunnels
- Guardwalls
- Roadway Pavement
- Maintenance Issues
- Existing Traffic Management Operations

Additional detail regarding conditions and feasible solutions is provided in *Chapter 2: Engineering Analysis and Site Recommendations* and in the Appendices.

Drainage. Rehabilitation, maintenance, and the addition of necessary drainage facilities are considered a high priority throughout the length of the Road. Road damage resulting from water intrusion into the highway pavement and base was especially evident in the Alpine Section. Discussions were held with Park Service personnel regarding areas of repeated debris accumulation and the difficulty experienced in removing this debris from drainage inlets and culverts. Corrections to drainage will be

Putting "weepholes" in the existing walls is not historically appropriate in locations where a guardwall is in place on top of a retaining wall, forming an unbroken plane of stone visible from outside the wall. However, the significance, stability, and integrity of the Road itself far outweighs the intrusion of a weephole. Weepholes could be acceptable in certain areas where there is no retaining wall under the guardwall. In these locations, the outlet should be as unobtrusive as possible. To achieve this, the outlet could be tilted down and skewed so that it is not parallel with the wall face. The hole should also be made in a mortar joint, not in the face of a stone. Doing this would constitute an effect on the contributing nature of the wall, but not necessarily an adverse effect. Inlets and an underground storm sewer would be significantly preferable to weepholes. Another approach would be a paved ditch to carry water on the cliff side of the Road. Cleaning and maintaining the existing Road drainage features would possibly eliminate the need for weepholes in many areas.

costly and the critical areas should be addressed as soon as practical. Areas not deemed immediately critical should be incorporated into other rehabilitation efforts in the same location. During these discussions and subsequent field reviews the following general observations were documented:

- ***Overall Roadway.*** Overall, many portions of the roadway and appurtenant structures are experiencing deterioration due to inadequate drainage conditions. Several of the existing drainage

Figure 6: In some areas, natural drainage flows onto and across the Road. Additional culverts or cross drains would alleviate these problems.

structures are not providing adequate drainage and water is damaging the roadway pavement, roadbase, retaining walls, guardwalls, and the drainage structures themselves. Locations were noted where natural drainage flowed onto and across the Road (Figure 6). Deterioration of these features can be slowed by addressing the drainage issues along the Road. Solutions include cleaning of drainage ways, replacing existing culverts with larger ones, adding culverts, installing weepholes or scuppers in stone walls, and properly locating cross-drains.

- ***Culverts.*** Most culvert crossings were generally in fair to good condition, with the exception of certain concrete box culverts (CBC) that showed evidence of abrasion and deterioration. Most corrugated metal pipe (CMP) culverts appeared to be sound, with very little evidence of corrosion and only occasional incidence of abrasion. In some areas, particularly just west of Logan Pass, the drainage structures appear to be undersized for peak flow periods. Rock and other debris partially blocked the entrance to several culverts and the interior of most culverts, inhibiting drainage (Figure 7). Removal of this debris should be made a top priority by the park.

Additional culverts may be added to the Road with no effect on its historic designation. Culverts should be placed with careful consideration to potential effects on the historic retaining walls and guardwalls.

Figure 7: Rock and debris partially fill the entrance and interior of most corrugated metal pipe culverts, inhibiting drainage flow.

Figure 8: A roadside catch basin presents a hazard to vehicles.

Historically correct protection of roadside catch basins would involve placing log barriers in front of the basins to block cars from them. These log barriers would be removed to facilitate snow plowing. In most cases, replacing historic catch basins with drop inlets would not be historically appropriate.

- ***Roadway Ditches and Cross Drains.*** Drainage is generally conveyed along the edge of the

Figure 9: A cross drain is choked with debris, rendering it ineffective.

Figure 10: High bed loading at Logan Creek Bridge narrows the water channel.

Figure 11: Bottom slab erosion at Haystack Creek reveals horizontal reinforcing bars.

roadway and into catch basins for dispersal. Catch basins exist along the edge of the Road; however, many of these are not grated and, due to their proximity to the traveled way, may pose a safety hazard (Figure 8). These catch basins should be modified to enhance vehicle safety with either log barriers or bollards.

Several drainage ditches and cross drains were choked with rock and debris, rendering them ineffective (Figure 9). Lack of continued maintenance of these facilities was evident throughout the field review.

Rock wall drainage ports, scuppers, and roadside ditch drainage facilities were too few in number and poorly maintained.

Repairing the base slab of the concrete box culverts will not adversely affect the historic character of the Road.

- ***Major Drainage Structures.*** Logan Creek Bridge (Figure 10), Haystack Creek Bridge, and Divide Creek Bridge all have high bed loading, which restricts flow. Each will require removal of this bed loading for proper flow and to reduce the deterioration on the structures and adjacent roadway.

Other box culverts and bridges along the Road are generally in fair to good condition, though notably not well maintained. Cleaning and repointing of the rock walls of these structures is needed throughout the length of the Road, in addition to repairs to the base of box culverts. Rock and debris abrasion has eroded the bottom of these culverts to the degree that reinforcing steel has been exposed, promoting further deterioration (Figure 11).

Bridges at Avalanche Creek, Baring Creek, and St. Mary River appeared to be structurally sound and generally in fair condition, with the exception of some mortar and stone guardwall deterioration. The FHWA has identified a problem with the Baring Creek Bridge in that the stone masonry is potentially unstable due to subsurface water behind the abutment walls and loss of mortar. The FHWA has designed a repair for this condition.

Significant drainage considerations/corrections are required throughout most sections of the Going-to-the-Sun Road. These include the repair of damaged box culvert base slabs and wing walls, establishment of additional cross-road drainage facilities, weep-holes or scuppers in stone wall structures, cleaning of rock and debris from drainage facilities and adjacent waterways, designing "maintenance friendly" drainage structures to facilitate cleaning and upkeep, interception of groundwater seepage into the roadway base and surface, etc. Safety, drainage, preservation of natural resources, and historic preservation are the controlling factors in good roadway rehabilitation.

Slope Stability. Slope stability issues include slump failures, slope undercutting, unstable slopes above and below the Road, and avalanche chutes. Stabilization of slopes is also considered a high priority throughout the length of the Road. Most all of the stabilization methods that require the scaling of rock and debris from slopes above the Road will require that traffic be stopped in both directions for safety. Depending on the specific area, these traffic stops can be from 30 minutes to a few hours, and should be scheduled to coincide with low traffic seasons. Field reviews and discussions with park personnel provided the following summary of conditions.

Figure 12: Weakened fill underlying the road.

- ***Slump Failures.*** Slump failures are generally limited to colluvium deposits and weakened fill sections adjacent to or underlying the roadway (Figure 12). Only a few notable slump areas were observed along the roadway. No evidence of imminent sudden movement was observed at the time of this review; however, continued slow movements can be expected as a result of seasonal conditions and water intrusion. Slump failure areas should receive detailed analysis as part of future roadway design efforts. No specific recommendations can be made regarding these areas without location-specific geotechnical investigation.

- ***Slope Undercutting.*** Slope undercutting of the roadway, due to soil raveling and shallow sloughing, occurs in a number of locations where steep slopes exist below the Road, especially in the higher elevations. This condition contributes to the weakening or failure of guardwall and retaining wall foundations and to loss of pavement and roadway width.

  Retaining walls, guardwalls, and roadway fill sections should be stabilized through areas suffering from slope raveling and undercutting. Erosion control on the affected slopes is also needed in these areas, utilizing redirection of surface water and armoring as appropriate. In some cases, erosion is probably exacerbated by avalanches.

  Retaining wall and guardwall foundations should be strengthened and extended below the slope's angle of repose a minimum of two to three feet. Erosion resistant stone and/or matting should be placed at the top of the slopes to arrest slope raveling and undercutting. Retaining walls and Road foundation support should be provided where necessary to re-establish roadway width and protect the slopes from further deterioration.

- ***Rockfall Hazards.*** Unstable slopes above the Road with rockfall hazards are considered a serious safety issue throughout most of the alpine section, extending from about one mile west of the West Tunnel to two miles east of Siyeh Bend. Rockfall hazards are also present in several limited locations along the east approach sections. Mitigation measures should be undertaken in order to minimize these hazards. However, the most effective types of mitigation for these conditions (cutting back slopes, rockfall sheds, etc.) would be extremely costly, and very intrusive on the visual and historic aspects of the Road. Mitigation measures could include scaling of loose rock masses and blocks, limited use of mechanical stabilization such as rock bolts, and restriction of parking and access in hazardous areas. Hazardous sections should be monitored before the Road is opened in the spring to identify where scaling needs to be completed as part of a regular maintenance program.

Figure 13: The most severe rockfall area is the quarter-mile section just west of Logan Pass.

In general terms, the scaling of specific rocks to eliminate specific rockfall hazards would be acceptable from a historic perspective. Scaling of rocks to improve horizontal or vertical roadway clearance would typically be unacceptable. Rock removed by scaling could be salvaged and used in the rehabilitation of the stone retaining walls and guardwalls.

The most likely section for severe rockfall hazards is the quarter mile section just west of Logan Pass, shown in Figure 13. The best type of mitigation for rockfall in this section would be to construct a rockfall shed or netting over the roadway. However, as noted above, this type of treatment would be highly intrusive on the historic and visual aspects of the Road. It is not deemed practical or effective to undertake scaling or bolting measures in this section.

Figure 14: Unstable soil slope above the Road at MP 35

Public awareness of landslide and rockfall hazards should be amplified with additional signing, visitor education, and other precautionary measures.

- ***Unstable Soil Slopes Above the Road***. In several locations steep, unstable soil cuts lie immediately above the Road. These soil cuts are subject to erosion, which is undercutting the ground surface at the top of the cuts. Such erosion also causes boulders to be eroded out from the soil material, leaving them free to tumble down the slope and onto the Road. Provisions must be made at these locations to retard erosion and/or to prevent boulders from entering the roadway.

- ***Avalanche Chutes.*** Avalanches are pervasive throughout the alpine area and continue to have an adverse effect on highway appurtenances. As their probability is very low during the peak visitor season, they are not addressed as a public safety issue for the Road. The current practice of using either a removable guardrail or an avalanche resistant guardwall along the Road where avalanche chutes are present is a prudent one and should be continued.

Figure 15: Debris flow at MP 37.

- ***Debris Flows.*** Debris flows have a significant impact on maintenance requirements and, potentially, roadway users. Debris flows are generally confined to gullies and drainageways; however, there is a hazard of sudden flow onto the Road, sometimes of considerable volume. There is little that can be done to prevent them. The flow of debris onto the Road can be reduced by placing barriers in the gullies and drainageways; however, they may be visually intrusive.

Retaining Walls, Arches, and Tunnels. The field reconnaissance teams examined the condition of existing stone retaining walls, arches, and tunnels on the Road. Retaining walls are closely inspected by the FHWA, with designs and construction underway for those deemed in need of critical repair. The FHWA has produced an inventory of the condition and proposed solutions for retaining walls, and the reader is directed to that report for details about specific locations.

- ***Stone Retaining Walls.*** Free-standing mortared rubble (stone) walls on bedrock foundations are the predominant type of retaining wall along Going-to-the-Sun Road.

  Considering the age of these walls, they are in generally fair condition, with a few notable exceptions. These exceptions include five walls that are considered damaged beyond practical repair due to failed foundations, water intrusion, and stone displacement. Portions of these walls must be rebuilt and FHWA will complete the work within the next two years.

Figure 16: Retaining wall at MP 27.

  Also, the upper three to eight feet of many of the walls are in distress, with loose or missing stones and crumbling mortar. Almost all of the mortared walls exhibit some degree of joint and mortar deterioration; these walls should be repointed (the old mortar removed to the extent possible and replaced with new mortar). In many instances vegetation is growing in the mortar, which indicates soil contamination and moisture intrusion. The bottom portions of the walls are generally in fair condition.

Repointing retaining walls will not have an adverse impact on these historically significant features of the Road. Care and the highest level of craftsmanship should be used to ensure that the finished product will be indistinguishable from original mortar work. This will require either identifying and using the original mortar mixture and materials (the most historically accurate approach), or emulating the appearance of this mortar as closely as possible. When necessary, rebuilding the historic retaining walls will be acceptable from the perspective of preserving historic resources if the wall is carefully disassembled and then reassembled with the same stone. The retaining walls must be reassembled in their original location. Use of concrete reinforcement may be acceptable in a reassembled wall as long as it is totally concealed by the finished stone product and results in no displacement of the wall from its original position. Replacements for missing stones should be collected from existing slopes or from rock scaling operations within the park.

The original retaining walls that were replaced with stone veneered concrete are not historically appropriate. However, it is not prudent to remove and replace these walls just to make them historically accurate, and the finished appearance was acceptable to the State Historical Preservation Officer. The stone veneer on some of these walls has not been completed. The most appropriate measure would be to remove the veneer and place the stone in a pattern that is more historically appropriate. Short of this, completion of the veneer is recommended so that the reconstruction is less noticeable.

The recently reconstructed retaining walls with concrete cores in the Haystack Creek area appear to be in good condition. However, the visual appearance of these unfinished walls is in direct contrast to historic structures in the area.

At a few locations the original stones from retaining walls have been replaced with non-native Minnesota granite. Although these stones appear to be performing well,

Figure 17: A portion of Crystal Point Arch has collapsed.

Crystal Point Arch is considered one of the finest examples of workmanship and classic design anywhere in the park. As such, it must be treated with the greatest of care. The craftsmen who originally built this arch selected and placed each stone carefully to match the color and texture of the stones around it. For exceptional structures such as this, it is recommended that, should any disassembly be required, the stones be numbered for correct reassembly.

Figure 18: Corrugated metal pipe underneath Crystal Point Arch.

they present a significant departure in appearance from the original stone.

- ***Dry Stack Retaining Walls.*** Generally, the dry stack retaining walls were in good condition and functional, with the notable exception of the Loop retaining wall, which is currently under rehabilitation by FHWA.

- ***Stone Arches.*** Most of the stone arches along the Road are in good condition except for minor to moderate mortar deterioration and weathering. One notable exception is the Crystal Point Arch which exhibits advanced stages of failure (Figures 17 and 18).

- ***Triple Arches.*** Deteriorating supports and guardwall sections were observed at Triple Arches (Figure 19). As shown in Figure 20, emergency corrective action has been taken by FHWA to shore up the weakened bearing rock support columns. The repair was undertaken in the late fall and was

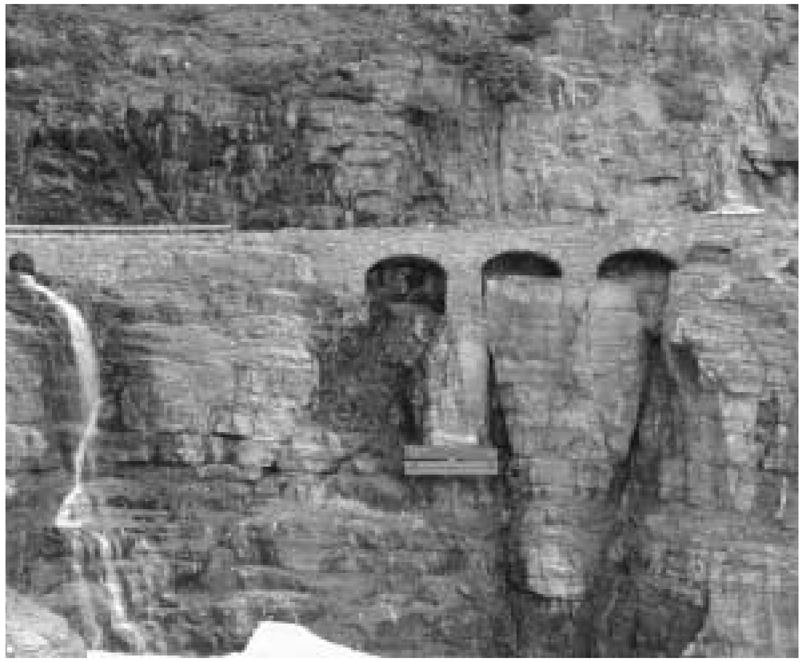

Figure 19: Triple Arches

Figure 20: FHWA's emergency corrective action used steel I-beams to shore up the weakened bearing rock support columns.

intended only as a partial fix to get through the winter. Although unsightly, this FHWA repair was effective. The design is complete for the remaining repair, which will replace the beams with rock bolting and restore the natural appearance. Additional stabilization efforts may be warranted in the near future to further shore up the structural bearing capacity of the retaining walls, adjacent rock stratum, and other structural elements, and to rehabilitate the guardwall sections.

Figure 21: West Tunnel

Figure 22: East Tunnel

- ***West Tunnel.*** No action is needed other than addressing rockfall issues and stone masonry repairs at the east portal and rockfall potential above the window vista near the tunnel's west end. Loose rock should be removed or stabilized in these areas as a safety consideration. Cracks in the tunnel lining appear well healed and are considered benign at this time.

- ***East Tunnel.*** The tunnel is in good condition and no action is needed at this time. Portal areas should be watched for loose rock, and scaled as appropriate.

Guardwalls. The field reconnaissance team examined the condition of stone guard-walls, guard rails, and barriers on the Road. Each of these is discussed in the following sections.

- ***Stone Guardwalls.*** There are basically two designs: 1) roughly squared large stones laid flat in a more or less ashlar pattern, usually with large cap stones; and 2) rubble stones consisting of various sizes and shapes laid in a random pattern and usually without cap stones. In general, the ashlar walls are in better condition than the random rubble walls. This may be due in part to the following three factors: 1) random rubble walls appear to be constructed of a stone of lesser durability than the ashlar walls; 2) the random rubble walls have a higher proportion of mortar per stone than the ashlar walls, and thus are inherently weaker; and 3) without cap stones, the random rubble walls allow for more intrusion of moisture into the wall, which accelerates deterioration of the mortar and stone.

Figure 23: In some cases, the distance from the top of the roadway to the top of the guard-wall is as little as six inches.

The majority of the stone guardwalls are leaning away from the Road or have been outwardly displaced from the roadway due to poor drain-

The guidelines for repointing and rebuilding historic guardwalls are the same as for stone retaining walls. Additional guidelines for the rebuilding of guardwalls include that the size (height, width, length) and location of the battlements (i.e. the "steps" that occur every so often) should be maintained; the historic type of guardwall, ashlar or random rubble, used at a particular location should be retained. If necessary, a concrete footer may be built underneath the guardwall before it is rebuilt as long as it is concealed by the finished stone product and results in no displacement of the wall from its original position (lateral, vertical, or horizontal).

Figure 24: Replacement mortar consisting of fine sand has almost no strength, and can be readily crumbled by hand.

age and foundations, avalanche and snow weight pressures, poor maintenance practices, etc. Many have also settled. The general condition of these guardwalls is considered poor, and the repair and reconstruction of certain sections is considered a high priority. Many of the guard-walls need repointing and other rehabilitation work.

Many of the stone guardwalls have settled and/or their height has been encroached upon by pavement overlays or patching. This results in the wall not being high enough in many places to serve its intended purpose of keeping errant vehicles from leaving the roadway. The low walls also may pose a safety issue for pedestrians at pullouts.

In some cases the distance from the top of the roadway to the top of the guardwall is as little as six inches, rather than 18 to 24 inches, as illustrated in Figure 23.

Figure 25: Removable sawed timber rail and steel post on concrete foundations.

The current sawed timber rail and steel post removable guardrail is not historic and its use should not be proliferated. Because it is historically inaccurate, replacement of existing installations is recommended. An acceptable alternative, in historic stone guardwall locations, is avalanche-resistant stone guardwall. This is a concrete stem wall with stone veneer that looks like original guardwall. Round-log guardrail designs have been historically used in some other locations, the reuse or adaptation of this design may be considered.

Some of the stone guardwalls appear to have been reconstructed or repaired with a mortar consisting of fine sand, such as would be used for brick or concrete masonry work. As illustrated in Figure 24, this mortar has almost no strength, and can be readily crumbled by hand.

The original mortar was constructed of native sands and contains red and blue pebbles about one-eighth inch in diameter. In general the original mortar is in fair condition except for the surface joints that have been exposed to weathering. As mentioned previously, moss and other vegetation grows on many mortar surfaces, contributing to the deterioration of the exposed surfaces.

- ***Stone Guardwalls on Concrete Foundations.*** At several locations the stone guardwalls have been reconstructed on concrete foundations, a repair not considered historic. These walls generally are not leaning and are not noticeably displaced horizontally; however, they are of a poor quality and workmanship.

In most locations, barrier rocks are not historically accurate and are not necessarily desirable from a safety standpoint. Most have been added since the 1950s or 60s, although it is reported that drawings from 1938 show isolated curb stones of 15 to 20 cubic feet for placement on the Transmountain Road. In most areas their function is to block vehicles from informal pullouts. These pullouts were created in many cases by maintenance activities that resulted in excess earth and rock material being deposited alongside the Road, resulting in a wide spot near the Road. The most historically correct action would be to remove the slide debris from alongside the Road and recontour the slope. Alternatively, the debris area could be revegetated. Either way, the informal pullout would no longer exist and the barrier rocks could be removed.

Figure 26: Large barrier rocks are used to block vehicles near the edge of a cliff.

- ***Removable Sawed Timber Rail and Steel Post on Concrete Foundation.*** These guardrails function as "removable" rails in avalanche zones and are generally in good condition (Figure 25). These guardrails were not intended to be crashworthy, rather only to serve as delineation. These removable guardrail systems are non-historic.

  Whether to replace all of these guardrails with historically appropriate guardwalls that are crashworthy is a subject of much debate, and the ultimate decision should be made by the park, as it will be of considerable expense. It is recommended that the replacement of these guardrails be made a low priority except in instances where crashworthiness is dictated. This replacement could be a removable wooden guardrail meeting crash-test and aesthetic requirements, or avalanche-resistant stone guardwall.

- ***Timber Log Rail and Posts.*** These barriers, which are in very good condition, are generally used to delineate the boundaries of parking areas, roadways, and driveways. They are not designed or intended to prevent errant vehicles from leaving the

Figure 27: Temporary concrete “Jersey” barriers replace missing guardwall, a dramatic visual departure from the original.

roadway. While not technically historic, they do mimic historic guardrails used elsewhere.

- ***Large Barrier Rock.*** Large barrier rocks are used in many areas to delineate the edge of the roadway or parking areas (Figure 26). Barrier rocks are placed to prevent vehicles from flying off cliffs. In some instances, these barrier rocks are considered a safety hazard in that they do not offer a continuous smooth transition through constricted areas as a guardrail would, and may cause severe damage to impacting vehicles.

- ***Temporary Concrete Barriers.*** At several locations the original guardwall is missing and has been replaced with temporary precast concrete roadway barriers, commonly called Jersey Barriers (Figure 27). These non-historic barriers offer an effective interim measure for traffic control and provide a barrier until a historically appropriate barrier can be installed. The Jersey barrier in some case reduces available roadway width to a certain degree. Further, these barriers present a dramatic departure from the visual appearance of the Road. It is recommended that these

The guardwalls are one of the primary contributing features to the designation of the Road as a National Historic Landmark. As such, they must be preserved with great diligence. The historic blunt ends of the walls have not been identified as a cause of vehicle accidents. Missing segments in existing guardwalls will likely be replaced during rehabilitation of the Road, resulting in fewer guardwall ends along the Road. Adding end treatments would unnecessarily affect the guardwalls’ historic significance and is not recommended.

In some cases, retaining walls and guardwalls can be added along the Road in areas where they did not historically exist without adversely affecting the historic nature of the Road. Adding a wall may have an effect on the historic nature of the Road; however, as long as it is constructed to emulate as closely as possible the nearby existing walls (materials, grout, color and placement of stones, workmanship, etc.) it should not be considered an adverse effect.

Figure 28: Cracks reaching down into the roadbed.

Figure 29: Alligator cracking.

Removal of existing asphalt and roadbed material will not have an adverse effect on features contributing to the historic designation of the Going-to-the-Sun Road. In fact, removal of removal of asphalt will be beneficial in some areas where excessive layers of asphalt have resulted in partial burial of significant guardwall and drainage features.

barriers be replaced with historically appropriate stone guardwalls or guardrails.

Installation of new guardwall should be considered at several potentially hazardous locations. An acceptable avalanche-resistant stone guardwall or crash resistant round-log guardrail could be used in these cases.

Most guardwalls observed had blunt terminals, which present a safety hazard to errant traffic. From an engineering perspective, this is generally undesirable; however, the blunt terminals have not been identified as an historic cause of accidents.

Roadway Pavement. The Road was originally constructed of different specifications relative to each construction contract. In general, the Road had a basic specification calling for four inches of 3/4-inch minus base course over the top of four inches of 1 ½-inch minus sub-base. This material was compacted, without benefit of additional water, by driving the haul trucks over the placed material. Such an operation would have created additional fines within these two layers, which allowed drainage to seep through. As a result, excessive voids have occurred, with subsequent settling and failure of the roadway and shoulders.

During the field reconnaissance it was noted that the Road had been rehabilitated in the western 16 miles during the 1990s. The area of Divide Creek was overlaid during the 1990s due to the flooding. These sections of roadway appear to be in good condition and should not require extensive rehabilitation at this time.

Exceptions to this general finding include minor bank erosion, pavement slumps, and surface deterioration problems adjacent to Lake McDonald.

Various stages of road distress were noted throughout the remainder of the route (MP 16.2 to 43.0) including surface chipping, longitudinal and transverse cracking, rutting, shoulder raveling, shoulder and edge-of-road subsidence, alligator cracking, and surface treatment (patching) to correct for settlement. Figures 28 and 29 illustrate advanced stages of pavement distress encountered on the Road.

Road sections in rock cut areas are generally quite stable with only surface deterioration noted. There were some rock cut areas where concrete slabs had been placed in the road bed to stabilize the roadway (MP 28). While these slabs have improved stabilization to a certain degree, they have also resulted in cracks in the overlying asphalt at the edge of each slab. Further, some of the slabs have tilted resulting in edges of the slab showing through the asphalt. The proper solution to the problem in this area is to improve the drainage so that the roadway foundation is kept dry and stable.

Road sections through geotechnically unstable areas of colluvial deposits (e.g., MP 34.5 to 35.3) will likely require extensive stabilization and reconstruction work to correct structural and surface deficiencies. Repairs could include removal of unsuitable roadbase material and replacement with suitable material with layers of geotextile fabrics or with anchored roadway concrete slabs.

Due to the absence of a proper roadbase, many of the turnouts and parking areas are badly cracked and rutted or chipped. Many of the shoulder areas are raveled and affected by erosion and weathering.

Many of the alpine and adjacent roadway sections are subject to subsidence of the outside lane, as noted by FHWA and verified during the field reconnaissance. Successive layers of asphalt pavement have been placed in many areas in an effort to maintain grade.

Appropriate repair of the areas outlined above will require removal of the existing failed asphalt; improved drainage where necessary to remove the destabilizing force of water from the roadbed; potential removal of the roadbed material and replacement with correctly sized, placed, and compacted road base; and placement of new asphalt surface.

Maintenance Issues

Proper maintenance of the Road is imperative to protect capital investments, preserve the historic nature of the roadway, and enhance the visitor experience. It was noted during the field reconnaissance that most of the Road's facilities are suffering from lack of proper maintenance. Drainage structures are plugged with debris and have fallen into disrepair; guardwalls and retaining walls have crumbled and shifted; roadway and pavement sections have deteriorated with extensive cracking and slumping in certain areas, and rockfall and other potential hazards have been left unattended. The park has comprehensive operations and maintenance plans to address these issues; however, it does not have the funding allocation to carry out these plans.

Some damage to roadway facilities due to the shear weight and movement of snow and ice is unavoidable; however, current methodologies, equipment, and procedures utilized in snow and ice removal are very effective in minimizing further damage. Park Service personnel indicate that snow and ice removal procedures have dramatically improved over the past decade with the addition of new equipment and procedures; however, considerable improvements are needed to address the needs of the Road. It was stated that in essence, Mother Nature determines when the Road will open. With the limited allocation of maintenance funding, consideration should be given to lessening expenditures on snow removal by delaying the opening of the Road for perhaps a week or two, in favor of a higher allocation to drainage maintenance.

The park should initiate a short-term, interim maintenance activity to clean out and repair plugged and damaged drainage facilities. Existing maintenance management plans should be reviewed, modified as necessary, and supported with sufficient resources to monitor drainage facilities on a regular basis, and to take necessary action to keep drainage structures clean, structurally sound, and operative.

A long-term maintenance program could be further developed, approved, and funded in order to preserve the integrity of Going-to-the-Sun Road, protect initial and subsequent investments, and enhance visitor experience. A significant outlay of funding is initially needed, possibly from a special allocation from funding authorities, or a private endowment. Creative financing is suggested as a way to supplement regular allocations. Possibilities include a vehicle/park usage surcharge assessed to visitors along with the normal park entrance fee, a public relations campaign to encourage public interest and donations for Road upkeep and rehabilitation, and local political and commercial support for maintenance needs.

Existing Traffic Management Operations

Traffic management at the existing FHWA construction sites was well designed and staffed. Lane separation and delineation for one-way and two-way traffic was well marked and operational.

Traffic control at the Loop consisted of advance warning signs and individual lane delineation for two-way traffic past the construction site at the time of the reconnaissance. Single-lane traffic, qualified traffic flaggers, and delays not to exceed fifteen minutes at a time were utilized as needed to accommodate contractor operations and facilitate traffic flow.

One-way alternating traffic control at the avalanche-resistant wall project in the vicinity of MP 30 was provided by qualified flaggers during construction activities and by temporary traffic signals at other times. Both systems were observed and found to be functional and effective. The maximum delay experienced at these sites during this review was five minutes per site, well under the prescribed maximum of fifteen minutes per site. Construction operations were proceeding in an effective manner as traffic was conveyed through the construction areas.

It was concluded from the existing traffic control operations, the field reconnaissance, and the team's previous experience with construction in alpine terrain, that much of the rehabilitation work can proceed using a one-way traffic control operation. There will be several projects, however, that will require traffic to be stopped in both directions -- especially the work associated with rock scaling, roadway pavement rehabilitation, retaining wall rehabilitation, and some drainage improvements. In many instances, two-way traffic stops can be limited to 30 minutes or less, but some projects will require considerably longer stops of four or more hours. Some of the work can be accomplished during the night. Other work, such as rock scaling, can only be done during daylight hours. The scheduling of the two-way stops should occur during low visitor periods insofar as practical.

The current guidelines used by the park for traffic control management may need to be modified in order to accomplish the work in an efficient manner while minimizing delays to visitors. It is recommended that during the preliminary design phase, the traffic control plan be individualized for projects in a given year based upon the most prudent means for accomplishing the work while at the same time minimizing the delays to visitors.

Current and Planned FHWA Work

Engineering analysis and roadway condition assessments conducted by the FHWA were reviewed and compared with the findings of the field reconnaissance. The FHWA condition assessments covered the same issues with respect to safety, preservation of roadway features and historically significant roadway elements, and general maintenance operations. It was noted that the FHWA condition assessments were thorough, accurate, and dynamic as assigned staff reviewed and updated roadway conditions on a regular basis.

The roadway deficiencies noted during the field reconnaissance were very consistent with FHWA's findings, especially with regard to pavement distress and retaining wall failure and deterioration. The primary difference between the FHWA assessments and the field reconnaissance assessment appeared to be the overall treatment of the drainage issue. FHWA has concentrated on immediate needs commensurate with available funding over the years, whereas the findings of the field reconnaissance emphasize long-term solutions for drainage, hydraulics, and roadway stabilization.

As a result of this comparison, the FHWA's condition assessment was verified as reported, and is considered substantially accurate. The priority roadway repairs identified by the FHWA (either underway or designed) were also verified, including the retaining walls and Crystal Point Arch.

General Conclusions from Conditions Assessment

The Road and its structures will continue to deteriorate unless corrective action is taken, especially with respect to drainage. If corrective action is not taken, historic structures and the environment will be negatively affected. Catastrophic events could affect roadway travel and thus decease visitor use. Carefully planned and designed rehabilitation projects, with attention to historic and cultural guidelines, preservation of natural resources, and visitor management -- along with a focus on minimizing long-term maintenance needs -- will assure the integrity of the Road well into the future.

With the passage of time and the combination of severe weather, traffic, under-funded maintenance, and other contributing factors, the Going-to-the-Sun Road has fallen into a state of deterioration and disrepair. The integrity of the Road has been compromised in terms of contributing to a “world class visitor experience” for the traveling public, since the visual aspects and physical serviceability of the roadway have deteriorated significantly and are considered to be very poor at this time.

The field reconnaissance concluded that the majority of the Road is in need of extensive rehabilitation in order to be responsive to public safety, environmental concerns, preservation of historic values and natural resources, socioeconomic impacts, transportation needs, and overall visitor experience.

General conclusions from the condition assessment include the following:

- ***Emergency repair projects*** already under construction, or designed and slated for construction, are considered to be of the highest priority and should be completed accordingly, including the five retaining walls identified by FHWA. Due to safety considerations, the repair of the Crystal Point Arch is also considered critical.
- ***Repair/rehabilitation of the stone masonry guardwalls at MP 32*** adjacent to the east tunnel should be considered a high priority due to their deteriorated condition and the narrow confines of the roadway.
- ***Drainage correction and rehabilitation*** is a priority item throughout most sections of the Road.
- ***Geotechnical problem areas*** such as slumps and unstable slopes should be rehabilitated as necessary, with design-level geotechnical investigations included where appropriate. Specific rock scaling operations should be considered in

areas of rockfall hazard. Additional signing and visitor education should be implemented to enhance public awareness of rockfall hazards.

- ***Stone masonry retaining walls*** should be rehabilitated and repointed as necessary. The top three to eight feet of many walls should be reconstructed due to advanced deterioration.
- ***Maintenance of existing facilities*** including rock scaling, drainage refurbishment, and pavement crack sealing is considered a priority in order to protect the historical and structural features of the Road.
- ***Roadway and pavement rehabilitation*** is required for approximately one-half of the roadway and associated parking areas. These locations are primarily from MP 16 to MP 43. Selective repairs and enhanced maintenance activities are also recommended over the remainder of the Road.
- ***Guardwall rehabilitation*** will be required on approximately two-thirds of the stone masonry guardwalls. All guardwalls should be examined and repointed as necessary.

The overall priority of rehabilitation is specified by Road segment in the chart below (Figure 30). In this chart, each segment is listed along with each rehabilitation need. The priority for each rehabilitation need is expressed by assignment of a 1 through 5 rating, with 1 being the highest priority.

Figure 30: Rehabilitation Needs by Road Segment

Item	Lake McDonald MP 0.0-16.2	West Tunnel MP 16.2-23.4	Alpine MP 23.4-34.3	Baring Creek MP 34.2-43.2	St. Mary MP 43.2-49.7
Drainage	5	2	1	4	3
Slope Stability	5	3	1	2	4
Retaining walls, arches, and tunnels	4	2	1	3	5
Guardwalls	4	2	1	3	5
Roadway pavement	4	2	1	3	5